

**CASE STUDY: USE OF VARIED UXO DETECTION APPROACHES AT FORT RITCHIE TO  
ACHIEVE MAXIMUM VALUE FOR CLIENT**

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**Abstract**

Sites contaminated with Unexploded Ordnance (UXO) do not always lend themselves to a single "correct" UXO characterization approach. Due to large variations in terrain, vegetative overgrowth, development, and fill materials present across the areas to be characterized for UXO, no single method/sensor was found to efficiently detect UXO items in all investigation sectors at Fort Ritchie Army Garrison in Washington County, Maryland. Performance testing and data quality requirements resulted in the use of traditional mag and flag techniques in two wooded/mountainous sectors, and the use of the Geonics EM-61 electromagnetic induction sensor in three developed cantonment area sectors. The technical approach utilizing the EM-61 provided a cost-effective method of detecting ordnance in areas of high cultural and metallic interference.

This paper describes the use of varied detection approaches during EE/CA sampling, QA/QC aspects of the EM-61 based ordnance location, and cost savings realized due to implementing EM-61 technology in the developed, cantonment area.

**Background**

Fort Ritchie is a 651-acre Army garrison located in Washington County, Maryland in the Blue Ridge Province near the Maryland-Pennsylvania border. Historically, the garrison was used for training by the National Guard and the U.S. Army Military Intelligence Center (MITC) from the 1920s to the 1950s. In 1995, Fort Ritchie was named as a Base Realignment and Closure (BRAC) site and aggressively scheduled for closure in 1998.

Based on an ordnance and explosives (OE) archives search of Fort Ritchie conducted by the U.S. Army Corps of Engineers (USACE) in 1996, six areas (Sectors 1, 2, 3, 4, 5, and 6) were identified as potentially containing unexploded ordnance (UXO). Sector 2 was subsequently removed from consideration after determination that potential UXO was no longer present due to post-range activity soil removal and terrain modification. Ordnance was characterized over a final area totaling approximately 300 acres.

Sectors 1, 3, and 4 (cantonment area sectors), located on the developed western portion of the Fort Ritchie cantonment area, were historically used as firing ranges of various distances. After the ranges were closed in the 1950's, the terrain associated with these sectors was heavily modified: roads, buildings, housing, and recreational areas including a golf course and ball fields were constructed over the former range areas.

Sectors 5 and 6 (undeveloped area sectors), located to the south and west of Sectors 1, 3, and 4, are densely vegetated areas with difficult terrain. Sector 5 was identified as an area that may have been used for munitions training and Sector 6 consists of a mountain-side impact area for munitions ranging up to 105 mm.

#### Summary of Historical Range Activities and Sector Use During EE/CA Sampling

Sector	Size	Post-Range Uses During Sampling	Historical Range Activities
1	37.3 acres	Base housing, PX, commissary, gas station, childcare center, youth center.	National Guard Firing Ranges – mostly 3" Stokes mortars.
3	32.4 acres	Base housing, golf course, sports fields, motor pool, commissary, childcare center.	National Guard Firing Ranges – mostly small arms.
4	24.4 acres	Base housing, DPW storage.	National Guard Firing Ranges – mostly small arms; MITC impact area, 3" Stokes mortars.
5	22.8 acres	Undeveloped wooded, wetland area, rocky terrain.	Believed to have been used for munitions training.
6	175.4 acres	Undeveloped wooded, mountainous, rocky terrain.	Impact area for munitions up to 105 mm.

#### Protection of the Public

EE/CA sampling started in May 1997 and was completed in June 1998 (before base closure). Based on the active status of the garrison during sampling and the high percentage of garrison acreage identified as former training ranges (i.e., almost half the garrison property), many challenges were encountered during sampling.

The management of the UXO field sampling required complex planning and day-to-day and often hour-to-hour coordination due to the active operations and population on the base. As shown in the table above, investigations of Sectors 1, 3, and 4 in the cantonment area impacted base housing, childcare and youth centers, PX, commissary, recreational areas, and other operations on base. Additionally, the investigations of the fringes of both Sectors 5 and 6 that lay adjacent to the cantonment area sometimes impacted base operations.

In order to safely perform UXO sampling and disposal activities under these populated conditions, exclusion zones were a major element of daily operations. Personnel within the exclusion zones were evacuated prior to the start of sampling activities and exclusion zone perimeters were barricaded and guarded to prevent access during sampling. Especially sensitive work areas, such as near the childcare and youth centers, were investigated with great care to minimize the impact to daily operations and maximize the safety of the occupants.

An additional safety measure that was added during sampling was the fabrication and use of engineering controls consisting of blast barricades to limit fragments if an unplanned detonation were to occur. These aluminum barricades consisted of three smaller "bud light" boxes and a fully enclosed barricade weighing over 3,000 pounds. The bud lights were used primarily on fringes of populated areas, limiting potential fragments in three directions, whereas the fully enclosed barricade was designed to limit fragments in 360°.

#### EE/CA Sampling Approach

The purpose of the EE/CA sampling was to characterize the ordnance types and density present in the five sectors identified as former training ranges. A statistically based ordnance sampling strategy was employed utilizing the SiteStats/GridStats sampling program (v. 3.01) developed by QuantiTech, Inc for the USACE, Huntsville Center (CEHNC). This program characterizes each sector for UXO density by performing random sampling of metallic anomalies until enough data is collected to make a statistically valid characterization of ordnance type and density.

Due to significant variations in the terrain and the abundance of fill material (significant quantities of non-UXO metallic debris and "hot rocks"), buildings, roads, and utilities in the developed cantonment area, two different survey techniques were utilized to located potential subsurface UXO at Fort Ritchie.

Sampling grids in the cantonment area sectors (1, 3, and 4) were surveyed with a Geonics EM-61 electromagnetic instrument, and grids in the undeveloped area sectors (5 and 6) were surveyed with handheld Schonstedt Model 52a and 72a magnetometers (i.e., conventional mag and flag approach).

#### **Mag & Flag Data Collection**

The use of the Schonstedt magnetometer was the only real survey option for the mountainous/wooded terrain of Sectors 5 and 6. Each investigation grid in these sectors was swept with magnetometers in lanes of no more than 5 feet width by EOD-trained personnel. At least 10% of the grid area was re-swept by QC personnel to ensure that all anomalies had been flagged. All anomalies were flagged and assumed to be potential UXO for the purposes of SiteStats/GridStats. Due to the sensitivity to small, near surface items and "hot rocks", the Schonstedt typically results in a greater number of anomalies than with the EM-61 instrument.

#### **EM-61 Data Collection**

The EM-61 approach for the cantonment area sectors was chosen after thorough evaluation of available UXO locating technologies and an onsite evaluation of two viable technologies (EM-61 and multi-sensor magnetometer) at Fort Ritchie within a test grid with significant cultural features. Based primarily on the test grid results, the EM-61 was chosen as the instrument of choice based on the better clarity of the survey results.

Each investigation grid was surveyed using search lanes spaced every 2.5 feet. The EM-61 instrument was primarily operated in trailer mode, readings were automatically taken at approximately 0.62 foot intervals along each survey line, as measured by an integrated survey wheel. Top and bottom coil data were collected at each measurement location. The data was recorded on an internal data-logger, and subsequently downloaded directly to a computer for storage and processing. Geonics software was used to review the data, generate profile lines, and convert toe survey line data to X,Y coordinates for contouring.

#### **EM-61 Anomaly Interpretation and Selection**

The initial anomaly interpretation and selection criteria were based on the results of on-site test pit calibration with simulated UXO. For each grid, anomaly target selection was initially performed by the geophysical subcontractor, NAEVA Geophysics, primarily based on line profile analysis. These picks and data were provided to ICF Kaiser and were reviewed and cross-checked against picks derived using OE-GIS Lite interpretation software provided by US Army Corps of Engineers, Huntsville Center (CEHNC). The interpretation and selection criteria were subsequently optimized in the field against actual dig and QA sampling results. The picks and data were then forwarded to CENAB for review. CEHNC also spot-checked select data sets and provided comment.

Comparison of profile-line response analyses against OE-GIS Lite analyses indicates that cross-interpretation yields superior results to either method individually; particularly in evaluating "marginal" or low amplitude responses, and increases quality control. Direct comparison of this interpretation approach to mag and flag results on three grids yielded more than a two-thirds reduction in false positives with no apparent increase in the false negative rate.

Long-term monitoring of EM-61 calibration pit lines across simulated UXO items and analysis of 10% replicate grid data showed acceptable data accuracy, precision, and comparability.

### **Initial Use of EM-61 in Sector 3, Grid 14**

Sector 3, Grid 14 was the first grid to be sampled based on data collected by the EM-61. The EM-61 evaluation of this grid originally identified 21 target locations, which were believed to be items of sufficient size meeting the performance criteria of a 60mm round at two feet, and a 105mm round at four feet, as specified in the scope of work. CEHNC recommended eight additional "low amplitude anomaly" excavation locations based on a geometric analysis of the original EM-61 data. A Schonstedt magnetometer was also used to flag all anomalies within the entire grid. A total of 625 Schonstedt anomalies were identified and flagged.

The EM-61 was used to reacquire the peak reading location within 3.0 feet of each of the 21 pick locations. The location of highest reading within 3.0 feet was identified and located. The EM-61 flags averaged approximately 0.9 feet away from the (X, Y) coordinates of the target locations originally selected.

The 21 original targets were excavated between 25 November and 10 December 1997. Of the 21 original anomalies, 15 consisted of non-OE scrap metal of various weights and depths. Six of the original 21 were ordnance related, including five practice rounds (3-inch Stokes mortar, 2.36-inch rocket, two 60mm mortars, and a 37mm M11 practice rifle grenade) and one live round (2.36-inch rocket).

The eight additional CEHNC recommended target locations were investigated by excavating the nearest Schonstedt anomalies. Excavation results identified hot rocks, small metallic scrap, and three small near-surface (<8-inch) inert training rounds. One of the training rounds was an empty, collapsed, 2.36-inch rocket head, with an approximate weight of 0.25 pounds. The other two items were practice M11 rifle grenades with an approximate weight of 0.5 pounds. Based on these results, the target selection response threshold was lowered and a 37mm round was added to the calibration pit.

Seventy-eight additional Schonstedt anomalies in the grid were intrusively investigated. No ordnance related items were found. All anomalies were hot rock, nails, pieces of wire, or small pieces of scrap metal.

### **QA/QC of EM-61 Anomaly Sampling**

Direct comparison of the selected EM-61 survey and interpretation approach to mag and flag results yielded a substantial reduction in false positives (non-UXO anomalies) without sacrificing safety. In the 48 grids sampled in Sectors 1, 3, and 4, QA/QC sampling of Schonstedt anomalies, at a rate of 10 to 30% of the selected EM-61 anomalies, detected no UXO or practice/training rounds.

Sample excavations proceeded until the source of the EM-61 anomaly was identified and removed if possible. At this point, a final (after excavation) EM-61 mV reading was recorded. The initial (pre-excavation) and final EM-61 readings were compared to ensure that the source of the anomaly was identified. Supporting information was also considered such as size, shape, and mass of the metallic item, the depth that it was found, the size of the excavation, the absence/presence of a peak in the data, and the amount of small metallic clutter in the soil. A detailed summary of the dig clearance process is provided in Attachment 1.

### **Summary of Sampling Results**

For the three cantonment area sectors surveyed with the EM-61, a total of thirty 50-foot grids and seventeen 100-ft grids were randomly sampled. A total of 1,615 target anomalies were identified in these grids, of which 949 were sampled. Of the sampled anomalies, 876 were miscellaneous metallic debris, 64 were non-hazardous ordnance scrap, and 9 were UXO.

For Sectors 5 and 6, a total of twenty-seven 50-ft grids and thirty-eight 100-ft grids were randomly sampled based on mag and flag results. A total of 5,875 target anomalies were identified in these grids, of which 2,309 were sampled. Of the sampled anomalies, 1,021 were miscellaneous metallic debris, 1,274 were non-hazardous ordnance scrap, and 14 were UXO.

### Cost and Time Comparison

The following summarizes the cost and time requirements for the two EE/CA characterization approaches utilized at Fort Ritchie.

#### Sectors 1, 3, & 4: EM-61 Approach

Total Area: 95 Acres  
Area Sampled: 250,000 square feet (6%)  
Anomalies Identified: 1,615  
UXO Digs: 949  
No. of UXO found: 9  
UXO per No. of Digs: 1 UXO per 105 digs  
Total Time: Two teams for 10 weeks

#### Sectors 5 & 6: Conventional Mag and Flag Approach

Total Area: 207 Acres  
Area Sampled: 447,500 square feet (5%)  
Anomalies Identified: 5,875  
UXO Digs: 2,309  
No. of UXO found: 14  
UXO per No. of Digs: 1 UXO per 154 digs  
Total Time: Two teams for 19 weeks

### EE/CA Sampling Cost Savings

Significant cost savings were realized by using the EM-61 survey approach over conventional mag and flag in the cantonment area of Fort Ritchie. This cost savings is due to a significant reduction in the amount of false positives (non-UXO anomalies) based on the comparison data collected in Sector 3, Grid 14. This data is as follows:

Mag and Flag: 625 anomalies  
207 digs (33%)  
8 holes/hour cleared = 26 hours  
Total estimated time for Sectors 1, 3, & 4 = **26 weeks**

EM-61: 29 anomalies  
20 digs (minimum of 20 digs)  
2 holes/hour cleared = 10 hours  
Total estimated time for Sectors 1, 3, & 4 = **10 weeks**

Based on this data, an overall 40% reduction in cost was realized utilizing EM-61 over conventional mag and flag in Sectors 1, 3, and 4.

ATTACHMENT 1 FLOW CHART FOR CLEARING/COMPLETING EE/CA  
EXCAVATIONS

